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TAXONOMY OF PROJECT COMPLEXITY INDICATORS IN ENERGY MEGAPROJECTS

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Abstract

A megaproject is characterised by its large size of investment, long project duration and high level of technical and process complexities. Megaprojects in the energy sector might include nuclear power plant construction, oil exploration and wind farm installation. There is strong evidence that these types of projects often experience problems in practice, partly due to the increased complexity and the lack of appropriate tools to evaluate and manage that complexity. In addition, a total absence of consensus on any definition of project complexity, as well as assessment criteria and indicators, has produced confusion amongst practitioners when evaluating project complexity in practice. This study aims to fill this gap by (1) systematically reviewing and synthesising literature on project complexity and energy megaprojects; (2) developing a project complexity taxonomy, which consists of a comprehensive list of indicators; (3) providing a method for determining the weights for different indicators in order to calculate a composite complexity index. The taxonomy consists of a total of 76 indicators, which are divided into two groups: external indicators and internal indicators. Each group is further divided into two and three levels respectively.

Key words

Energy; Megaprojects; Project complexity; Taxonomy

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1 INTRODUCTION

“Megaproject,” a notion of rising importance in today's worldwide business environment, invites a closer examination as a result of the alarming rate of failure and the complexity of managing such projects. It is crucial to observe and address the features that can contribute to a removal of the causes of such fails. In general, these huge projects or as called in this research Megaprojects, have been defined as mega-size projects involving more than one billion U.S. dollars capital [1-4]. They are usually described as risky, complex, with high uncertainty and socially tense impact, whilst engaging many stakeholders [5].

On the other hand, energy will be the only essential that the world will be in need of in the future. With an average annual growth rate of 1.6 percent, it is estimated that the world’s energy need should be more than 50 percent higher in 2030 than 2007 [6]. With this high demand from modern societies for energy, the nature of energy projects in size of tasks and capital investment has grown to become very large and complex [4]. Research by the Independent Project Analysis Institute (IPA) demonstrates that many of the large, complex capital projects carried out in the past 20 years in the energy sector (e.g. large scale power plants or offshore platforms) have been unsuccessful in meeting their business goals or suffered cost overruns at an alarming rate [4, 7]. A report by the International Energy Agency highlights the resources from the fields with “easy accessible oil” have already been extracted and the new fields to be exploited are located in more difficult areas (e.g. deep water or remote areas), growing the complexity to be faced in trying to achieve the project’s goals [7, 8]. Studies of global energy companies and NOCs reveal that the largest risk to project delivery is the incapability to adequately determine and adapt to such projects’ complexity [9].

Complexity has been the topic of research and a challenging issue in industry since the early part of the industrial era, but from the nineties, project complexity was considered as one of the main factors to be taken into account when organising projects [10, 11]. Baccarini [1] brought the first important model of project complexity as he addressed both the organisational and technological characteristics of the problem. More recently, research has been carried out to better realisation from concept of project complexity [12-18] and to plan the bond between complexity theory and project management [19]. The large number of recent works and related papers on project complexity highlight the apparent standing of “complexity” in present project management research. The mentioned research presents a theoretical vision and, in some works, integration of theory and practice. However, from the authors point of view, not only is there a total lack of consensus in subject and definitions, but also no robust framework, based on both theory and practice, exists that supports the characterising of project complexity or effectively assesses the level of complexity. Specifically, any understanding of the notion of megaproject complexity evaluation is absent.

Identifying a project complexity score could almost certainly help the project team to take appropriate management actions to reduce the potential likelihood of uncertainty and other damaging issues that might affect project performance. As a result of this lack of information, theoretical and practical, complexity in megaprojects, and in particular the energy sector, is still perceived as a sort of black box; what indicators and criteria precisely cause complexity in projects is neither fully understood nor agreed. To build up a rich and comprehensive framework, the first bricks needed in place are accurate and settled definitions and terminology. However, it can be seen that the literature survey highlighted a diverse assembly of terminology and a range of confusing indicators used by different studies to describe the concept of project complexity.

This paper reviews existing research with the target of creating contemporary knowledge concerning project complexity in energy megaprojects. The first aim of the authors is to develop the taxonomy in order to create ease of application for the user, as well as providing a generic terminology to understand project complexity through a robust and systematic logic. Furthermore, in many of projects it is more useful and effective to quantify a general aspect, instead of multiple detailed indicators, due to the nature of the project: macro rather than micro. This research intends to establish two distinct taxonomies which are broad and inclusive, assembling most of the related project complexity criteria and indicators mentioned in previous research, pertaining to either general or energy megaproject topics. In addition a methodology is provided by applying the Delphi method as well as using the Analytic Hierarchy Process (AHP) to demonstrate how the developed taxonomy leads to a project complexity assessment (PCA) framework.

1.1 Research question

In order to develop the taxonomy based on the literature survey, the main research question to be answered in this study is:

Based on the literature relating to project complexity and energy megaprojects: how to identify a comprehensive taxonomy of project complexity indicators, which will effectively help to increase project performance and support the establishment of the PCA framework?

The question recognises elements of the project environment which contribute to project complexity and how they should be considered in the complexity assessment process in energy megaprojects.

1.2 Research methodology

This paper synthesises the existing literature in this field in order to establish a detailed sketch of project complexity. An initial review highlighted that research on project complexity includes a wide range of variables including complexity theory, structural complexity and uncertainty, risk and complicacy. On the other side, idiosyncratic attributes of megaprojects are key elements to aid the understanding of causes for such projects failing and other complexity issues within megaprojects. Given the high number of published studies relating to this area, it is necessary to identify the boundaries and scope of the research. The main focus is on project complexity from the project management perspective and specifically the energy megaprojects sector. The sources of literature yielding references relating to project complexity are published journal papers and books. However, the scope is broader when dealing with energy megaprojects' literature and includes conference papers, industry reports, company financial reports, white papers and media extracts due to the newness and scarcity of studies in this field.

1.3 Structure of the paper

The literature review is presented in Section 2, followed by the explanation of how the taxonomy of project complexity indicators is established in section 3. The methodology to reach project complexity assessment framework from taxonomy is described in Section 4. Conclusions are discussed in Section 5.

2 LITERATURE REVIEW

The literature review addresses different definitions of project complexity and complexity related, idiosyncratic attributes of energy megaprojects. As a result, it identifies indicators which, it is suggested, contribute to project complexity and exist in the literature of project complexity

2.1 Project complexity

To determine the project complexity indicators, firstly definitions of complexity are studied. The absence of a clear and unequivocal definition of project complexity in the literature is demonstrated [19]; a problem also stressed by Parwani [20] when he describes the concept of project complexity as "lacking a uniformly accepted definition". For this research the definition of project complexity put forward by Vidal et al., [21] which is developed, based on and generally informed by other works [1, 17, 22] is proposed: "project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system." Despite the ambiguity of defining complexity, project complexity is characterised by a range of different authors. Table 1 presents an overview of principal project complexity aspects gleaned from the literature.

Table 1: Overview of principal project complexity aspects of literature

Author	Aspects of project complexity
Baccarini, [1]	Organizational and technological
Williams [18]	Structural and uncertainty
Vidal et al., [21]	Technical and organisational
Bosch-Rekveldt et al., [22]	Technical, organisational and environmental
Cicmil et al., [23]	Complex adaptive systems and socially constructed elements
Brockmann and Girmscheid, [24]	Task, social and cultural
Remington and Pollack, [25]	Structural, technical, directional and temporal
Geraldi, [26]	Fact, belief and interaction
Whitty and Maylor, [27]	Structural, dynamic and interaction features
Kardes et al., [28]	Technical and social

Whilst there are similarities between aspects of complexity highlighted in table 1, a degree of diversity and lack of consensus on the identification is obvious. In addition, several issues highlight their limits such as: instability of reliability, final user can hardly use due to the need for high levels skill and knowledge, and a biased focus on specific issues like cost, instead of focusing on the project environment itself [21]. The works by Remington and Pollack [25], Bosch-Rekveldt et al. [22] and Kardes et al. [28] discuss aspects of complexity in megaprojects and large engineering projects, but cannot precisely connect project complexity aspects to idiosyncratic attributes of megaprojects.

2.2 Idiosyncratic attributes of megaprojects and complexity

One concept to define the megaprojects is to consider the size of the project, typically by capital size. The evidence of 60 "large-scale engineering projects" showed the average project size of $985m [29]. While there is no universal or standard definition for the term "Megaprojects", these projects are defined as mega-infrastructure projects with more than $1 billion capital [1-4], financing mainly by government or giant enterprises and being carried out by both public and private sectors. The current European studies consider a minimum of €500m as the mega size of a projects' capital [4].

To narrow the subject of this research, the key sector of energy is chosen. The energy industry has shown a rapid move from medium size to megaprojects as governments and enterprises announce projects across the world, utilising trillions of capital over the coming years on diverse types such as traditional oil, gas and coal or renewables such as: wind power, hydroelectric, solar photovoltaic, biomass, biogas and biofuels [30]. Despite this evolution, the industry failed to achieve the expected goals and crucial overruns in budgets and time are frequent happenings. Unlike the subjects of megaprojects in transportation, urban and infrastructure, which have received significant attention in order to identify and address the root causes of failures in recent years of energy megaprojects operation, as a distinct topic, scarcely appeared as a subject for research [29].

To address the main causes of failures, firstly the idiosyncratic attributes of megaprojects should be investigated and identified. Megaprojects are regarded as harbouring high levels of complexity, through a lens of uncertainty and ambiguity, requiring the establishment of a temporary enterprise for the project's execution, having significant political and external impacts and involving a long term, but urgent, operation period [17]. Three issues are mentioned as the main causes of failures in megaprojects: high levels of resource deployment; high internal and external impact on the project's environment; and extreme complexity [3, 4, 31]. However, the study by Procaccini et al. [9] blamed the inability to adequately determine and adapt to a project's complexity as the largest risk to project delivery in the field of mega capital energy projects. The complexity of megaprojects is highlighted by a number of aspects such as tasks, resources, finance, as well as a number of uncertainty issues and their interactions [29, 32]. Moreover, research results by van Marrewijk et al. [33] suggest the main complexity criteria comprise: the large size, long project period, diversity of technological disciplines, the number of stakeholders and multi-nationality among them, the conflicting decision makers, rising costs over time, market risk, uncertainty, and highly captivating for public and in politics [3, 33]. Similar to the topic of project complexity, there are confusing and diverse aspects to address regarding the complexity of megaprojects. To develop the taxonomy project concerning the identification of complexity indicators, several literature sources, including those mentioned in this section, have been used to identify the indicators from the literature perspective. Literature databases were investigated for the most relevant articles relevant to the topic of project complexity.

2.3 List of project complexity indicators from the literature

Despite the inherent dynamic features of complexity within a project, this research principally focuses on the project complexity indicators that should be considered before project operation is started. This is because the effective use of this list, in developing the PCA framework, assumed its use in the project initiation stage. In total 76 project complexity indicators were obtained from the literature review and are highlighted in Table 2. In the views of the authors of this paper, the presented indicators show the most relevant aspects of project complexity in general, megaprojects in particular, or both.

Table 2: list of project complexity indicators derived from literature

Indicator from literature	References	G/M
Applicability of project management methods and tools	[17]	G
Availability of information	[3, 24]	G-M
Availability of people due to sharing	[1, 17]	G
Availability of Physical resources	[3, 17]	G-M
Changing economy	[3, 17, 28]	G-M
Changing technology	[1, 3, 9, 34, 35, 36]	G-M
Combined transportation	[34, 37]	G
Contract types	[14, 22]	G-M

Cultural configuration and variety	[38, 39, 40]	G
Cultural differences	[38, 39, 40]	G
Degree of obtaining information	[4, 24, 36, 41, 42, 43, 44]	G-M
Degree of processing and transferring the information	[45, 46]	G
Demand of creativity	[47, 48]	G
Dependencies between schedules	[38, 39]	G
Dependencies between tasks	[4, 8, 14, 17, 22]	G-M
Diversity of staff background	[8, 14, 17, 23]	G
Diversity of task elements	[24, 49, 50, 51, 52]	G-M
Duration of project	[3, 14]	G-M
Dynamic and evolving team structure	[34, 48, 53]	G
Experience with parties involved	[4, 14]	G-M
Experience with technology	[1, 22]	G
Geographical location of the stakeholders	[54-57]	G
Institutional configuration	[1, 58]	G
Integration of more than one information system system or platform	[8, 17]	G
Intensity of project dusration	[8, 24]	G-M
Interaction between the technology system and external environment	[8, 17]	G
Interdependence between sites, department and companies	[34, 55, 57, 59]	G
Interdependence between the components of the product	[34, 55, 57, 59]	G
Interdependence of information systems	[34, 39, 60]	G
Interdependence of objectives	[8, 17, 28]	G
Largeness of capital investment	[4, 8, 14, 17]	G-M
Levels of interrelation between phases	[53,61, 62, 63]	G
Market competition	[17]	G
Market unpredectibility and uncertainty	[4, 17]	G-M
Local laws and regulations	[24, 34, 36, 41, 42, 43, 64, 65]	G-M
Newness of technology	[3, 4, 14, 17, 28]	G-M
Number of decisions to be made	[4, 40, 66, 67]	G-M
Number of groups/temas to be coordinated	[34, 37, 68, 69]	G
Number of system components	[1, 8, 14, 17]	G
Number of tasks and activities	[24, 39, 46,70, 71, 71, 73]	G-M
Organisation internal support	[14, 22]	G
Organisational degree of innovation	[1, 35]	G
Political influence	[3, 14, 24, 28]	G-M
Process interdependence	[14, 17]	G
Relations with permanent organisations	[1, 8, 35, 36]	G
Reliability of information platforms	[47, 57]	G
Resource and raw material interdependencies	[55, 59]	G
Scope changing	[3, 8]	G-M
Significance on public agenda	[64, 65, 74, 75]	G
Specifications interdependencies	[1, 17]	G
Stability project environment	[14]	G
Team cooperation and communication	[34, 48, 53]	G
Technological degree of innovation	[1, 3, 8, 34, 35, 36, 39, 47, 48 58, 61]	G-M
Technological process dependencies	[10,11]	G
Time pressure	[4, 57, 67]	G-M
Transparency of Objectives	[14, 17]	G
Trust in contractor	[14]	G
Trust in project team	[14, 17]	G
Uncertainty of goals	[3, 14]	G-M
Uncertainty of the project management methods and tools	[14, 17, 19, 24]	G-M
Unpredictability of tasks	[38, 48, 64, 75, 76]	G
Variety of financial resources and investors	[24, 38, 39, 40]	G-M

Variety of departments and hierarchical levels involved	[61, 62, 63]	G
Variety of organisational skills needed	[67]	G
Variety of product components	[24, 36]	G
Variety of project management methods and tools applies	[14]	G
Variety of resources	[1, 14, 61]	G
Variety of solutions/paths/path-goal	[34, 36, 61, 64]	G
Variety of stakeholders interest and perspective	[4, 14, 17]	G-M
Variety of technological dependencies	[4, 17, 40]	G-M
Variety of technological skills needed	[34, 53]	G
Variety of the technologies used during the project	[3, 24, 36]	G-M

A number of identified indicators in the literature review are not considered in or for this list, due to irrelevance. To keep the clarity of the list, indicators with similar meanings have been merged together. In case an indicator shows a very general meaning, such as risk, the indicator is not separately considered in the list, but it is covered by other indicators. As this research is about project complexity, it omits subjective indicators such as manager competency [47]. The right column of Table 2 shows whether the indicators appeared in the general project complexity literature or in a megaproject.

3 DEVELOPMENT OF TAXONOMY

Given the fact that project complexity is a difficult measure to quantify [22], many researchers aimed to classify the complexity aspects, based on different and diverse logics. It seems all of the studies are established by having been based on the foundation of previous studies and a novel and robust classification has not developed yet. This paper aims to develop a taxonomy of project complexity indicators which provides a clear, simple and effective platform for the end user. Taxonomy in general is defined as the practice and science or study of classification of subjects, things or notions, with the philosophies that justify such classification [77]. It is widely used in science, from natural studies like biology to management and business or IT. In this research, the principles of taxonomy are derived from the PRINCE2 project management standard provided by the Office of Government Commerce (OGC) [78].

The proposed taxonomy presents a hierarchical structure in two distinct groups based on this probe that each element in the project environment is within the project or imposed from outside [78] which are related to internal or external elements respectively and formed Level1 of taxonomy:

- External: The indicators in this level are mainly outside the control of project delivery organisation and related to external stakeholders like government. This group is further divided in two more level includes environmental, political, and legal and regulations, economy and social aspects of project complexity which form Level2 of taxonomy here. Corresponding 10 indicators were allocated to each aspect depends on relevance which construct Level3.
- Internal: this group is combined with engaging aspect within the project environment and categorised into three further levels. The probe to determine the taxonomy in Level2 is based on PRINCE2 themes. On each project, three questions address three main themes and consequently aspects of level2:
    1. What? Is related to “Project characteristics”. It discourse attributes of project itself which construct Level3 of the hierarchy including technology and objectives.
    2. Who? Is linked to “Project delivery organisation/team” and includes matters of that in Level3 as people, disciplines, capital and physical resources.

3. How? Is associated with "Process of delivery of project" and includes tasks, information, tools and methods and time in Level3.

Implementing this systematic approach helps the user to understand the degree of complexity in project and build up an effective assessment system. The breakdown in Level3 is self-explanatory and defined based on the nature of project complexity indicators which fit in each group of Level2. The establishment of Level4 is allocation of each indicator among identified 66 indicators into a related Level3 group. It is assumed that each indicator can only sit in one level and group based on distinct definitions of taxonomy levels. Stand on aforementioned discussions, the taxonomy of project complexity indicators is presented in tables 3 and 4 for external and internal indicators in turn.

Table 3: Taxonomy of external indicators

Level1	Level2	Level3	ID
External (E)	**Economy (EC)**	Changing economy	EEC1
		Market competition	EEC2
		Market unpredectibility and uncertainty	EEC3
	Environmental (EN)	Stability of project environment	EEN1
		Interaction between the technology system and external environment	EEN2
	Legal & regulations (LE)	Local laws and regulations	ELE1
	Politics (PO)	Political influence	EPO1
	Social (SO)	Cultural configuration and variety	ESO1
		Cultural differences	ESO2
		Significance on public agenda	ESO3

Table 4: Taxonomy of Internal indicators

Level1	Level2	Level3	Level4	ID
Internal (I)	**Organisation/ Team of delivery (Who?) (OR)**	**Capital resources (CA)**	Largeness of capital investment	IORCA1
			Variety of investors and financial resources	IORCA2
		Disciplines (DI)	Contract types	IORDI1
			Variety of departments and hierarchical levels involved	IORDI2
			Variety of different Disciplines, norms and standards	IORDI3
			Organisation internal support	IORDI4
			Relations with permanent organisations	IORDI5
			Team cooperation and communication	IORDI6
			Institutional configuration	IORDI7
		People (PE)	Availability of people due to sharing	IORPE1
			Variety of different nationalities	IORPE2
			Trust in contractor	IORPE3
			Trust in project team	IORPE4
			Diversity of staff background	IORPE5
			Dynamic and evolving team structure	IORPE6
			Experience with parties involved	IORPE7

			Number of groups/teams to be coordinated	IORPE8
			Variety of organisational skills needed	IORPE9
			Variety of stakeholders interest and perspective	IORPE10
		Physical resources (PH)	Resource and raw material interdependencies	IORPH1
			Variety of resources	IORPH2
			Geographical location of the stakeholders	IORPH3
			Availability of physical resources due to sharing	IORPH4
	Process of delivery (How?) (PR)	**Information (IN)**	Availability of information	IPRIN1
			Degree of obtaining information	IPRIN2
			Degree of processing and transferring information	IPRIN3
			Reliability of information platforms	IPRIN4
			Interdependence of information systems	IPRIN5
			Integration of more than one information system or platform	IPRIN6
		Tasks (TA)	Combined transportation	IPRTA1
			Interdependence between sites, department and companies	IPRTA2
			Process interdependence	IPRTA3
			Levels of interrelation between phases	IPRTA4
			Number of decisions to be made	IPRTA5
			Number of tasks and activities	IPRTA6
			Unpredictability of tasks	IPRTA7
			Variety of solutions/paths/path-goal	IPRTA8
			Dependencies between tasks	IPRTA9
			Diversity of task elements	IPRTA10
		Time (TI)	Duration of project	IPRTI1
			Time pressure	IPRTI2
			Dependencies between schedules	IPRTI3
			Intensity of project duration	IPRTI4
		Tools & methods (TO)	Uncertainty of the project management methods and tools	IPRTO1
			Applicability of project management methods and tools	IPRTO2
			Variety of project management methods and tools applies	IPRTO3
	Project characteristics (What?) (PC)	**Objectives (OB)**	Diversity of goals and objectives	IPCOB1
			Interdependence of objectives	IPCOB2
			Transparency of Objectives	IPCOB3
			Uncertainty of goals	IPCOB4
			Scope changing	IPCOB5
		Technical (TE)	Demand of creativity	IPCTE1
			Repetitiveness of processes	IPCOB2
			Variety of technological dependencies	IPCOB3
			Newness of technology	IPCOB4
			Experience with technology	IPCOB5

			Interdependence between the components of the product	IPCOB6
			Specifications interdependencies	IPCOB7
			Technological process dependencies	IPCOB8
			Number of system components	IPCOB9
			Variety of product components	IPCOB10
			Organisational degree of innovation	IPCOB11
			Technological degree of innovation	IPCOB12
			Variety of technological skills needed	IPCOB13
			Variety of the technologies used during the project	IPCOB14
			Changing technology	IPCOB15

4 METHODOLOGY TO DEVELOP THE PCA FRAMEWORK

The establishment of the taxonomy is the main foundation for development of the project complexity assessment framework. However the work involved in the development of the framework is beyond this paper; but a brief description of methodology provides an insight into the implementation of the taxonomy. This research has tried to comprehensively present a list of indicators, but they are from sources with various perspectives and diverse contexts. Hence, it is imperative to deploy an evaluation process to choose the most important and relevant indicators with sufficient scope to handle energy megaprojects. In addition, all levels of taxonomy are assumed with equal weight, but in reality, each aspect or indicator has a different impact on the complexity measure of a project. Therefore a method based on the previous data or experience of experts should be used to obtain each aspect or and indicator's weight. Also, each weighted indicator needs a precise scoring measure in order for the user to evaluate project against complexity indicators. The final complexity score of the project will be gained from an aggregation of all scores. The Delphi and the Analytic Hierarchy Process (AHP) methods were chosen to operate the described method.

The Delphi method will be used to gain the most consistent consensus from a panel of experts by running a series of questionnaires, combined with organised opinion feedback, and then results of each round will be fed into the next round [79]. The process of Delphi execution usually consists of the accurate selection of experts with the most relevant profile, design of appropriate questionnaire and analysing the answers [80, 81]. The AHP was developed by Saaty [82-84]. It is a multi-criteria decision-making method which deploys prioritisation of alternatives. The AHP is implementing the use of pairwise comparisons from the expert's perspective, which results in obtaining a ratio scale for each alternative.

The Delphi method to be applied in following research will be run through three rounds with 30 nominated experts which carefully chosen from industry and academia with extensive experience in energy megaprojects.

- Round 1: respondents will be asked to review the list of project complexity assessment indicators in Level4 and allocate a score on a five-point Likert scale. In addition they will review the Level3 aspects and have the pair comparison among them to obtain the corresponding weights of those aspects and that level by using AHP method. In result of this round, Level4 list of indicators will be reviewed and based on the statistical analysis, most relevant indicators will be kept and remain removed from the list.

- Round 2: the respondents will be provided with the results from round 1 and will be asked to rework their Level3 aspects pair-comparison. Also they should provide the pair-comparison of the all level4 indicators.
- Round 3: respondents are asked to reconsider the weights of Level4 indicators based on the consolidated results from round 2 and also review the scoring measure of these indicators on a 2-way answer (Agree-Modify). Figure 1 shows the process of methodology to establish the project complexity assessment framework.

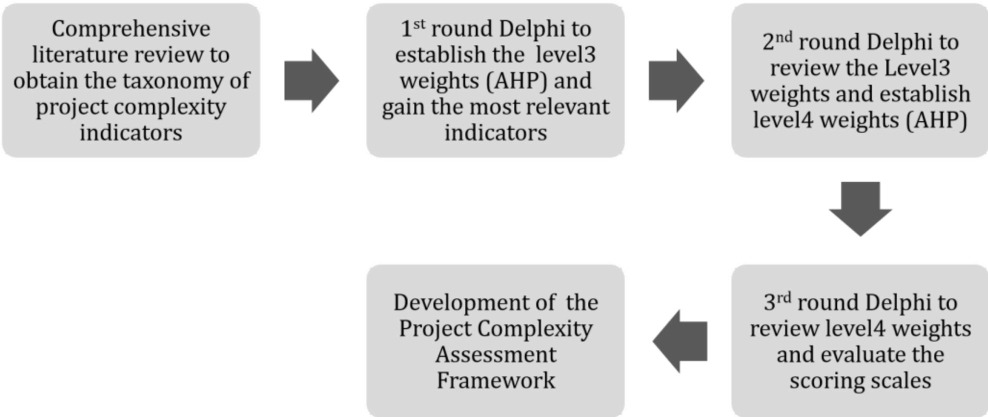

Figure 1: Methodology to develop the project complexity assessment framework from taxonomy

5 CONCLUSION

Project failure in energy megaprojects can be avoided by effective control and adaptation of project complexity assessment. Complexity in energy megaprojects is driven from a range of idiosyncratic aspects such as size, tasks, resources, finance, technology and uncertainty. Despite a large number of research studies regarding the topic of project complexity, a lack of consensus and specific methods developed for megaprojects has weakened the efficiency of project management methods. Existing literature addresses different aspects of project complexity. This paper establishes a comprehensive overview of the topic and as a result of analysis, provides a taxonomy of project complexity indicators on two distinct groups: external and internal. The external group is categorised into two further levels and the internal class into three more levels. The taxonomy of indicators is designed to help provide a clearer understanding of complexity in megaprojects and ease the process of quantification of complexity and its causes. This paper also provides a complete reference for academics and practitioners relating to the subject of project complexity and energy megaprojects.

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